CAN CLIMATE CHANGE INCREASE THE LIKELIHOOD OF STATE FRAGILITY?

by
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Abstract

It was concluded that climate change can influence the fragility of a country. The existing academic literature has found that it can be as nuanced as the displacement of people due to drought, flooding, storms, forest fires, and other natural and human-related forces. These scenarios can lead to a large influx of climate refugees into foreign regions that under some circumstances may result in localized conflicts due to competition for resources and/or cultural and ethnic differences. A rapid and persistent change in environmental conditions such as caused by drought has direct consequences for those that rely on the natural resources. A sudden and persistent change in the natural environment can be analogous to how other species may need to migrate in order to survive. Mankind is no exception here, specifically those that are dependent on arable land for farming and have no other means of income or food security.

A mass migration can have potentially destabilizing effects on nearby countries and the world due to the interconnectedness of globalization. The case of Syria's civil war is the most prominent case of how climate change contributed to the violent conflict. A powerful drought outside of natural variability and linked to anthropogenic climate change forced Syrian farmers to abandon their lands and into the outskirts of urban cities in pursuit of work. A strain on resources due to unsustainable water policies also resulted in a classic case of environmental scarcity which further exacerbated the drought crisis. During this time, the Arab Spring protests encouraged revolutionary tendencies in neighboring countries and as a result, also spread to Syria. The displaced farmers added fuel to the unrest in Syria. The underlying themes associated with conflict and unrest,

such as mass migration and resource scarcity, are indirectly applied to conclude that a changing climate has the potential to disrupt a stable country and have cascading destabilizing effects internally and to neighboring countries. Statistically significant findings also suggest that there is a high correlation between temperature anomalies and the fragility of a country. However, there is no simple link between climate events and instability. Countries with a relatively poor governance structure are most susceptible to exogenous natural forces due to their assumed low adaptive capacity to deal with natural disasters and/or mitigate their impacts. The correlation of the year to year variations between temperature and the number of displaced persons, which is a driver of state fragility, are weak. But the upward trends of the number of globally displaced persons and temperature are strongly correlated.

Preface

Climate change is not solely an ecological issue; it is also a political, moral, and economic one. The fact is that our world operates almost entirely on fossil fuels such as transportation, power generation, and cooking – all of which require, from a macro perspective, some form of carbon-intensive fuel. It is relatively cheap to do so because of decades of innovation and infrastructure dedicated to getting more people access to these products.

I was motivated in learning more about climate change after hearing stories about the dreadful conditions of a drought in Taishan, China from my mother. In 1986, she described instances where her neighbors and friends were fighting over the water well; some have even killed others with gardening tools as weapons. The hostility had led to violent deaths and overall despair. After understanding that increased drought activity was possible under the theory of climate change, I decided to investigate further.

Acknowledgements

I want to thank Dr. Richard Seager & Dr. Daniel S. Zachary for their help in reviewing my capstone draft reports and providing comments/insights from their significant scientific backgrounds.

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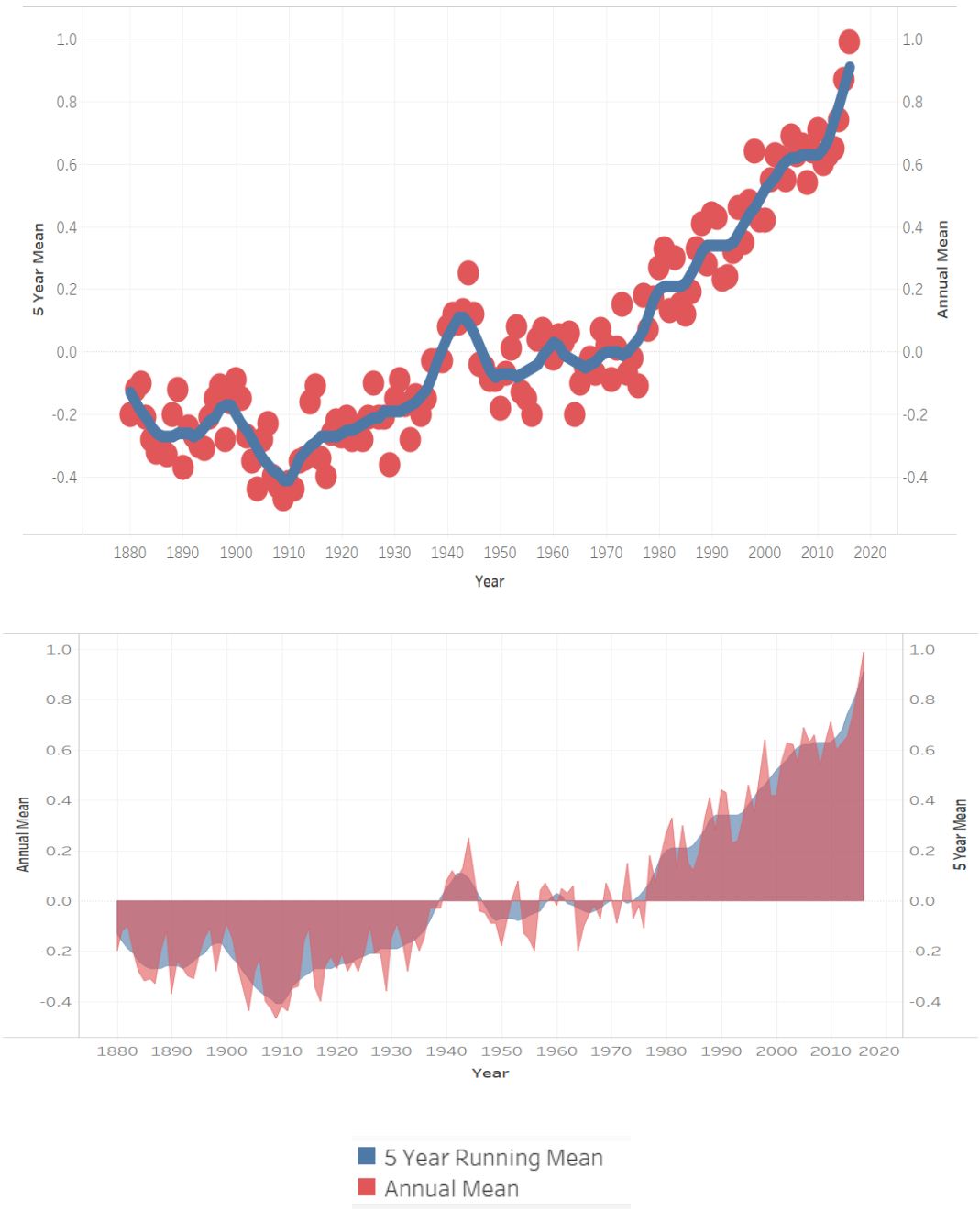
Introduction – Climate Change in Context

Climate change has been a foreign policy issue since before the Kyoto Protocol, but it was only until recently that the international community has acknowledged it as a security issue as well (Paskal, 2007). In 2013, Navy Admiral Samuel Locklear, the Commander of the U.S. Pacific Command, identified climate change as the Pacific region's biggest long-term security threat. Climate change "is probably the most likely thing that is going to happen… that will cripple the security environment, probably more likely than the other scenarios we all often talk about." (CNA, 2014) Anthropogenic greenhouse gas emissions from the industrial, commercial, transportation, and residential sectors will contribute, according to the scientific literature, to future food price spikes, displacement of populations, and water scarcity. This may ultimately lead to instability, conflict, and violence in fragile regions, which may impact the world as a whole due to globalization. Geopolitical stability has always been a primary goal for national and international security (CNA, 2014). More than 50% of countries now incorporate specific references of climate change in their defense policies (Scott et al., 2016). Scientists from around the world are increasingly becoming more and more confident in their ability to narrow their projections and reaffirm that anthropogenic climate change will destabilize the globe. Such results can take the form of longer fire seasons, acceleration of sea-level rise, the collapse of sea ice in the Arctic Ocean, movement of vector-borne diseases towards higher latitudes, precipitation becoming more irregular and/or concentrated, and increased stress to freshwater systems due to prolonged droughts (CNA, 2017).

About half of the world's population resides in urban environments now. Urban living promotes more resource intensive lifestyles that puts upward pressure on power consumption and waste production. The world is also becoming more affluent which further reinforces the belief that there will be an even greater number of resource-draining lifestyles. It is believed that projected impacts of climate change will strain limited resources and negatively impact governments' ability to provide basic and necessary human support systems, reducing its legitimacy and creating vulnerability to social unrest as populations faced with hardship grow susceptible to extremism and other radical stimuli (CNA, 2014). Climate change could act as a threat multiplier or, a catalyst for conflict around the world (CNA, 2014).

From the United States' Department of Defense's 2014 Quadrennial Defense Review, the effects from climate change are recognized as aggravators of already existing stressors such as poverty, environmental degradation, political instability and social strains, which are situations that can enable terrorist activity and other forms of violent movements (QDR, 2014). There is a growing understanding that access to essential resources and the reliability of critical infrastructure are at risk. Climate change may greatly exacerbate existing problems, but in the absence on climate change, these problems would still exist (Paskal, 2007). Further, since climate change projections contain significant uncertainty due to initial conditions, climate model biases and emissions uncertainties, precise projections of future climate-induced social instability are not possible (Hawkins et al., 2015). Consequently, some climate security assessments have made indeterminate claims that suggested the environmental change was not a pressing issue for the military services and reactive policies are the only options available

(Briggs, 2010). In addition, misconceptions such as climate change being only limited to gradual increases in air temperature, will ultimately hurt countries in which their militaries do not understand that even a small change in air or water temperature can have a large impact on ecological systems. Indications of climatic and environmental impacts will become more obvious in the near future, but what these changes will signify in the context of worldwide and local security will require a larger number of effective translators to bridge the scientific communities with the national militaries and disaster response entities (Briggs, 2010).



Figures 1 & 2. Both graphs represent the 5 year land-ocean temperature running mean from 1880 to 2016 in blue and the annual mean in red. X-Axis signifies years and Y-Axis signifies the Temperature Anomaly in °C. Dataset sourced from NASA's Goddard Institute for Space Studies and constructed in Tableau.

Methods & Hypothesis

The linkage between violent conflict and climate change is extremely complicated and needs to be better understood in order for policymakers to design comprehensive plans in their efforts to adapt to a world where the effects of anthropogenic climate change are becoming more prominent. A significant portion of the world mostly functions on a basis in which natural resources are exploited such as in agriculture. There is a dependence on the natural world and hence a vulnerability to climate variability and change. When an abrupt, frequent and/or persistent negative climatic event occurs, this can lead to unwanted implications such as social and civil unrest.

To answer the question of 'does climate change contribute to increasing state fragility?' we can review the existing literature and leverage the existing academic capital already amassed. This should steer a direction for an independent experiment to be conducted, it is also necessary to ease any bias one may have developed. The datasets used here have been sourced from independent entities with no agenda other than to report and document data. These datasets will be subjected to statistical scrutiny such as to account for outliers that may skew the data in an unmeaningful and false direction. The objective is to review correlations between key indicators of a nation's state fragility – such as the amount of internally displaced people, government effectiveness, and quantified state fragility – with climatic data such as temperature anomalies. The results will be used to infer likely explanations for the correlative outcome if such a correlation exists. The datasets will be cleaned and treated in Excel 2016 and Tableau 10.1 Public for data visualization and analysis.

Some of the data will be treated for outliers by calculating the Median Absolute Deviation (MAD) value for all the datasets and omitting all data points outside of the median x 2.5 the Median Absolute Deviation (Leys et al. 2013).

$$\boldsymbol{Median\ Absolute\ Deviation = median}(|\boldsymbol{x - median}(\boldsymbol{x})|)$$

The primary analysis tool will be Excel's ANOVA (Analysis of Variance) regression utilizing F-statistics. Pearson correlations (*r*) will be calculated to determine whether or not an association exists between two variables; the value is between -1 and 1. A higher absolute *r* value signifies a stronger linear correlation. A 0.3 *r*-value is a weak correlation, 0.5 is a moderate correlation, and 0.7 is a strong correlation. Negative r values reflect inverse relationships with the same numerical concept. Results will be within a 95% confidence interval and classification of independent and dependent variables will be made throughout the report. Analyses will be conducted on both the correlation strength of the trends as well as the correlation between the year-to-year variations.

The null hypothesis is that a country's fragility has no association with temperature anomalies, the number of internally displaced people, and/or government effectiveness.

$$\boldsymbol{H_0 = not\ enough\ evidence\ to\ prove\ correlation\ between\ the\ datasets}$$

The alternative hypothesis is that a country's fragility can be a function of temperature anomalies, the number of internally displaced people, and/or government effectiveness.

$$\boldsymbol{H_A = sufficient\ evidence\ to\ prove\ correlation\ between\ the\ datasets}$$

To determine whether two variables are statistically significant, a p-value below an alpha (α) of 0.05 is required.

$$\boldsymbol{p < \alpha = statistically\ significant}$$

$$\boldsymbol{p > \alpha = not\ statistically\ significant}$$

If the p-value is lower than the alpha of 0.05, the null hypothesis will be rejected since there is sufficient evidence to conclude that there is a significant linear relationship between the two variables.

If the p-value is higher than the alpha of 0.05, the null hypothesis will not be rejected and there is insufficient evidence to conclude a statistically significant linear relationship between the two variables.

I hypothesize that climate conditions such as increased land and sea temperatures will negatively affect the world's nations and lower stability worldwide. Countries with high fragility will be particularly sensitive to climate variations, including rising temperatures caused by increased greenhouse gases. I further hypothesize that the amount of internally displaced people within a country is directly associated with how fragile a nation is and also dependent on the temperature anomalies. Precipitation is likely to be at least as important as temperature in the context of state fragility, the scope of this report does not capture the role of precipitation because no plug and play dataset was readily available. Granular and gridded precipitation data exists but would take extensive data cleaning to be aggregated up into the regional classifications necessary for analysis.

Water Variability

The projected effects of climate change have the potential to alter water variability and river flow. Rivers such as the Jordan and Tigris-Euphrates in the Middle East are expected to experience reductions in stream flow. But other basins such as the Congo in equatorial Africa and the La Plata in South America, will experience increases in flow, adding to inundation issues. Climate change and its role in water variability is expected to increase security concerns between countries or within regional river basins. Predictions of 'water wars' have been made in reference to nations heavily dependent on natural water resources. Shared water management strategies may, however, evolve because of the desire to avoid possible political tensions and violent conflicts associated with the sharing reducing freshwater resources. Research suggests that higher water variability over time may drive nations to cooperate further; at least until variability increases beyond a certain threshold, then cooperative behavior is negatively affected (Dinar, 2017).

Regions comprised of developing countries that have a substantial reliance on climate-sensitive resources may lack the ability to deal with and adapt to climate change impacts effectively. There are over 800 million global citizens that have no access to safe and clean water; this is projected to reach an overwhelming 2 billion people by 2050. Just 2% of the Earth's water is freshwater but almost half of this 2% is not usable for human consumption due to pollution and evaporation. A growing human population will be competing for limited water resources, a problem compounded by climate change with its adverse impact on water sources and enhanced levels of flooding and drought. From a

2008 Technical Report of IPCC, it is claimed that increased precipitation intensity and variability will increase the hazards of flooding and drought in many areas, affecting food stability, water quality and intensifying many forms of water pollution. Another layer to be considered is the pollution levels in many of the world's regions, which have reached widespread and hazardous levels that compromise water security. Lastly, the impacts from flooding, drought, saltwater intrusion, erratic weather patterns, and elevated water-borne diseases will challenge existing water security and supply for millions. China and India, the two most populated countries in the world, will face significant water scarcity challenges that may result in internal conflict (Pink, 2016).

Given the security implications of climate change impacts on water, international water treaties may prove essential to ensure hydro-political related stability. Even in regions without formal agreements, transboundary waters will nevertheless still require effective management and water agreement commitments (Dinar, 2017). But even water treaties can be broken when pressures grow too great. The Indus Waters Treaty between India and Pakistan, which was in effect for more than 60 years, and is an area of cooperation between the two adversaries, had been threatened to be revoked by India after Pakistan-based terror attacks in 2016. It was still however, unlikely to have been rescinded due to the foreseeable international condemnation that would have resulted; but the fact remains that upstream nations have and potentially will employ tangible leverage over downstream nations. This can have cascading effects, such as inspiring China to do the same and reduce flows of the Brahmaputra River to downstream India (CNA 2017). This will ultimately bring about complex discussions for human and international security as the United Nations Commission on Human Security defines human security

as: “To protect the vital core of all human lives in ways that enhance human freedoms and human fulfillment. Human security means protecting fundamental freedom — freedoms that are the essence of life. It means protecting people from critical (severe) and pervasive (widespread) threats and situations.” Furthermore, the U.N. General Assembly approved a landmark human rights statement sustaining that water constitutes a “human right” in 2010 (Pink, 2016). Thus, another layer of complexity will need to be injected into the already difficult topic of ensuring international security among countries and will require additional solutions.

Decreased water availability can be a chief cause of civil unrest and localized violence. Especially when combined and compounded by other existing negative facets such as poor water management, corrupted governments, or pre-existing social tensions. Water issues can also bring nations to the negotiating table to participate in diplomatic discussions. But in the same respect, water stress can also be exploited by non-state actors such as violent extremist organizations that can weaponize water. Because of its essential value, threats to, or taking control of, water infrastructure and supply can be used by organizations to advance their interests. For example, this sort of activity may force those that do not want to take part in any violence, into situations where they must support groups in order to receive water and food (CNA, 2017). Water stress and its influence in conflict is also relevant to state-on-state conflicts. As nations experience greater water stress due to population pressures, migration, and climate change – water insecurity can magnify existing tensions between nations. Although it is not likely that water will start a major war, it still can exist as a contributing factor (CNA, 2017).

Food Security

Water scarcity can also lead to sharp increases in food costs, which has direct correlation with stability. Rising food prices can cause riots and social unrest as illustrated in Figure 3 (Bellemare, 2014). China for example, will experience significant climate change impacts from drought, floods, aridification, saltwater intrusion that could lead to, rising food and grain prices, public health crises, vulnerability to malaria due to warming temperatures, and environmental refugees, all of which will have extensive bearing on food security. Government functionality and the ability to contain epidemics of all kinds can have a substantial effect on preventing associated risks to government legitimacy. Government intervention and capacity building may also have unintended consequences when they are not entirely scoped out and can potentially worsen an already fragile scenario. Even with economic meltdowns aside, climate change will exert pressure on water security, food security, and the overall world economy. Non-climatic circumstances such as overpopulation can also induce food insecurity but climate change likely aggravates impacts. This coupling of impacts will require special governance and international cooperation to reduce the risk of food insecurity as well as strengthen ties between countries to stimulate more inclusive trade (Ane Cristina Figueiredo Pereira De Faria et al., 2016). However, trade also has the potential to work both ways – if there is a decline in global production, the wealthiest market participants may have the incentive to buy up scarce resources making this food scarcity more intense and further reducing availability to others, specifically the poor. In circumstances where countries are becoming more globally interconnected and dependent on imports for their food supply,

the global food system would exhibit similar characteristics to that of a fragile nation who is vulnerable to self-propagating disturbances. Super-efficient and globally connected markets allow for the possibility to make this theoretical inequality even greater. And extreme weather anomalies could trigger this global systemic disruption (Puma et al., 2015).

Droughts have exposed several issues that hamper effective responses to the core problem, such as a lack of irrigation systems, insufficient water reserves, inadequate drought emergency management, and generally weak capacity to adapt to persistent and severe droughts. This is particularly concerning in China, as noted by the author Yunnan Chen, "China's central and local governments have good reason to be concerned. The effects of water shortage and pollution are not merely ecological, but also have implications for social stability. In 2005, there were around 50,000 environment-related protests. Though official statistics are difficult to find, the number of such protests has reportedly been growing at an average rate of 29% per year from 1996 to 2011." (Pink, 2016)

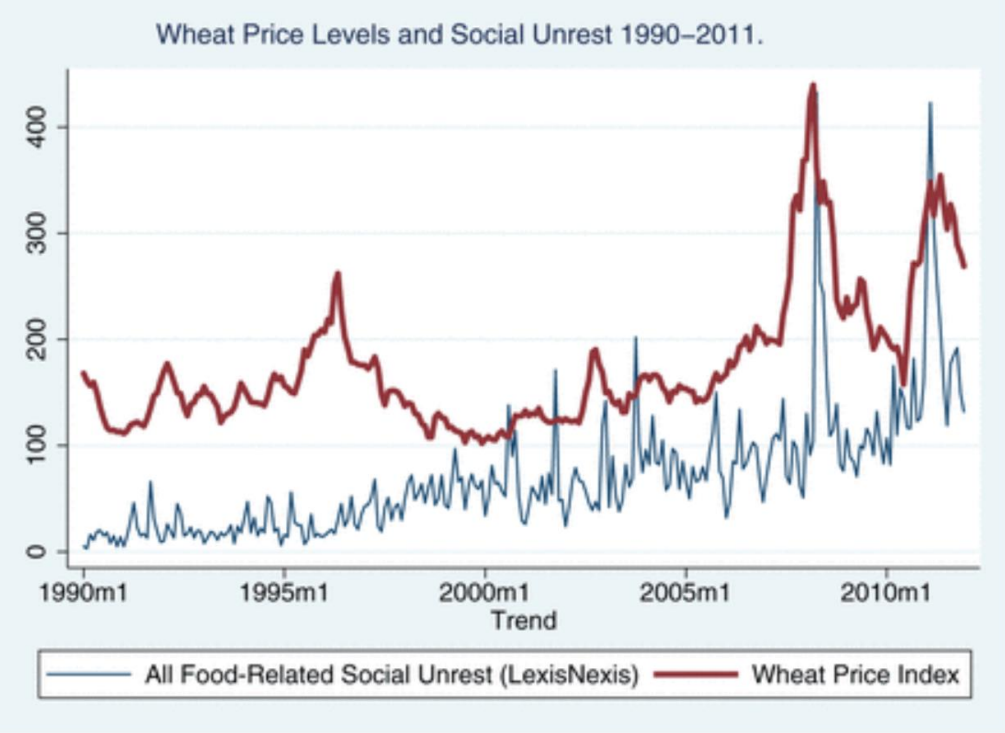


Figure 3. (Bellemare 2014)

Mass Migration

Environmental scarcities have been contributing to violent conflicts in many parts of the developing world and may be indicative of more to come in the future as resources become even scarcer. These environmental scarcities can swell social impacts, such as population movement, economic deterioration, and the weakening of states. These can contribute to persistent sub-national violence, with the rate and extent of such social conflicts increasing as scarcities worsen (Homer-Dixon, 1994). Historians have also claimed that the El Nino Southern Oscillation (ENSO) may have driven global patterns of social conflict in the past, which emerging research confirms (Hsiang et al., 2011). ENSO

influences a variety of climatological variables, each of which may plausibly influence how conflict-prone a society may be (Hsiang et al., 2011). The violence as a result may be both localized, persistent, and drawn-out. Those in poor communities will be primarily affected considering that their communities are often underserved, have little to no buffer enabling surviving through poor years and are often highly dependent on foreign and domestic government assistance. These poor societies are already suffering from grave hardships due to shortages of water and fertile land.

Migration is an environmental adaptation and response to the local environmental conditions such as the availability of food and seasons. Mass migration can produce prospects for constructive change in the distribution of wealth and land as well as a beneficial change in governance. But unpredictable surges can overwhelm efforts at useful social reform; once a tipping point is reached, societies may contain either fragment or become more authoritarian when state institutions cannot meet the demands of its citizens (Homer-Dixon, 1994). Fragmented countries will be a source of excessive out-migrations and may be unable to effectively negotiate international agreements on security or trade due to its poor validity as a viable and functioning country. There may not be assurance that these fragmented countries will continue to exist in the near future and thus communications with other countries may be limited. If they are converted to be authoritarian regimes, they may be inclined to attack neighboring countries to divert media attention away from internal pressures as well. All of which has the potential to disturb international security (Homer-Dixon, 1994).

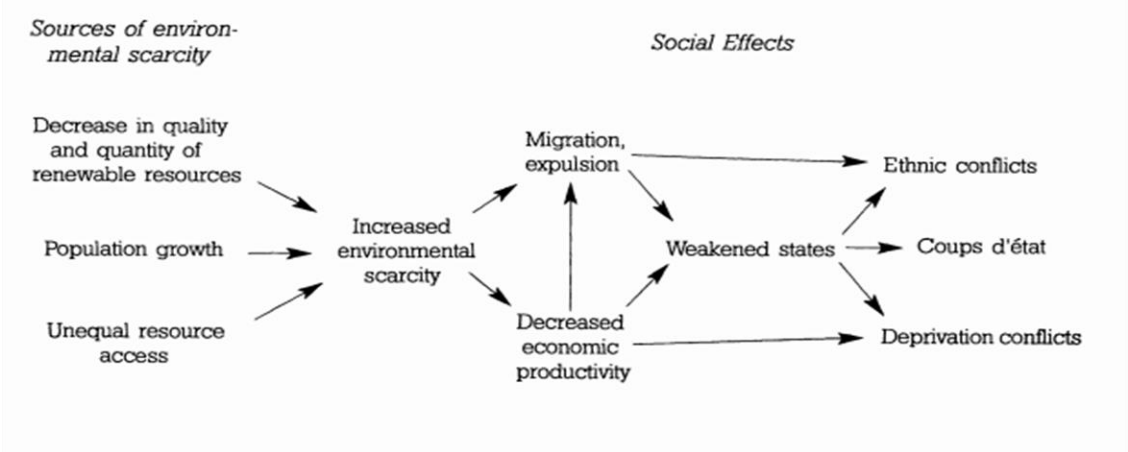


Figure 4. (Homer-Dixon 1994)

Findings from a growing volume of rigorous quantitative research across multiple disciplines suggest that past climatic events have exerted considerable influence on human conflict. This influence appears to extend across the world, throughout recorded history, and at all gauges of social institutions. Although climatic events are not conclusive as the sole or primary driving force in conflict, it was concluded by Hsiang et al. that when large climate variations do occur, they can have significant effects on the occurrence of conflict across a diversity of settings (Hsiang et al., 2011).

In comparing the datasets of Global Land and Ocean Temperature Anomalies (dataset from NOAA National Centers for Environmental Information) against the Number of Internally Displaced Persons (IDP) (dataset from the Center for Systemic Peace via the Internal Displacement Monitoring Center), there is a moderate association, with a Pearson Correlation (*r*) of 0.71. The temperature anomaly (°C) represents a departure from the long-term average for year 1910 to 2000 (NOAA). The results are also statistically significant with a p-value of 1.49E-07. The number of internally displaced persons represents the aggregation of all displaced people in the world for every year

from 1964 to 2008 and was normalized for growth in population by dividing the global IDP by the world population for his respective year (population data sourced from The World Bank) to account for the strong population growth seen throughout the world. The correlation suggests that as temperatures rise it may increase the number of IDP. This finding does not include shock or extreme climatic events such as prolonged droughts, aridification, intense rainfall, flooding, forest fires, and unpredictable hurricane tracks that are all made more likely due to anthropogenic greenhouse gas emissions. One particular interesting thing to note here is the increase in the number of displaced people in the late 1980s to 1990s and then a decrease since, even as temperature continued to rise. Upon applying a heat map to the raw data-sets to isolate the countries that are causing this uptick, Liberia dominated the amount of IDPs. The 1989-1996 Liberian Civil War was long in its gestation, it was rooted in the very foundation of the state (Sirleaf, 1991). It is unclear whether or not the climate had direct influence over the first Liberian civil war. The year-to-year variations between temperature and the number of IDP have a poor correlation and are not statistically significant.

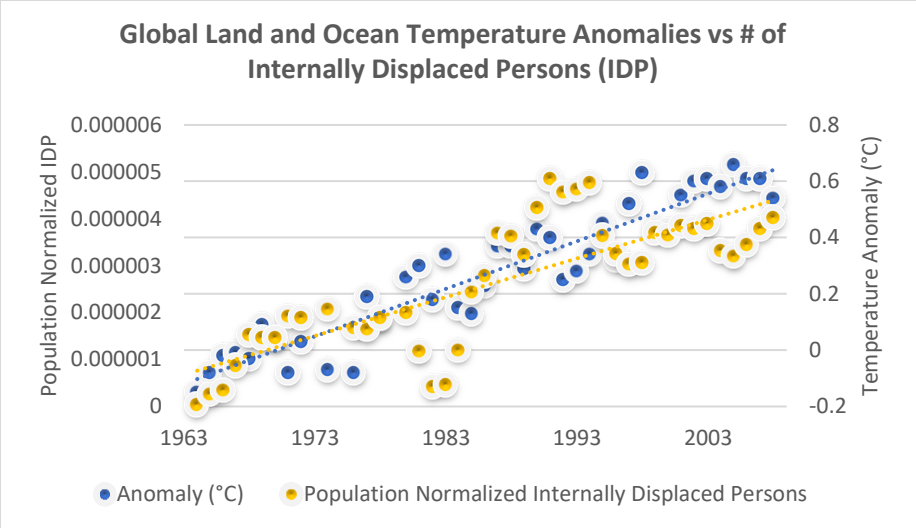


Figure 5. Global Land and Ocean Temperature Anomalies vs # of Internally Displaced Persons (normalized for population growth); Years 1973, 1975, and 1979 were omitted due to lack of data. Pearson Correlation (r = 0.71) (p-value = 1.49E-07). The independent variable is Anomaly (°C); the dependent variable is the Population Normalized IDP

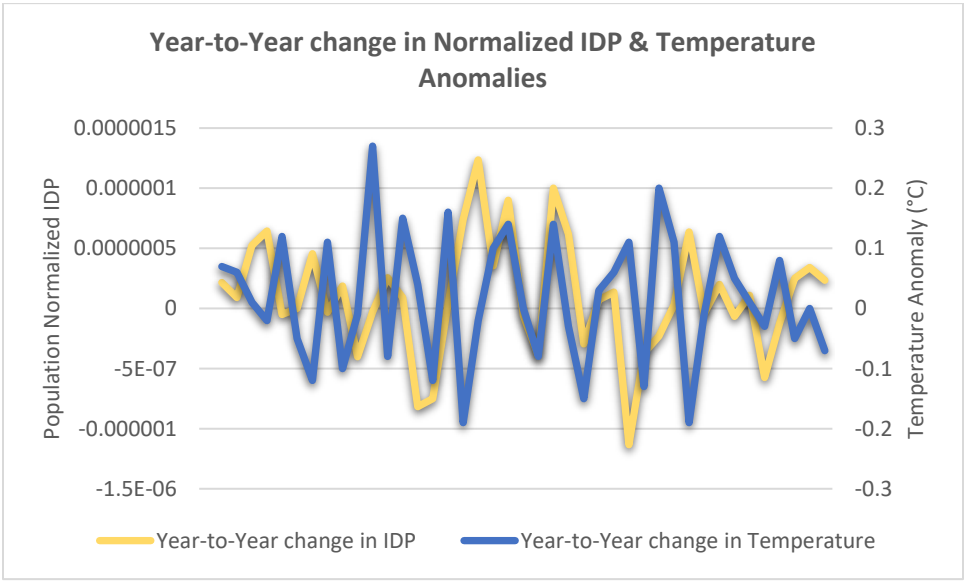
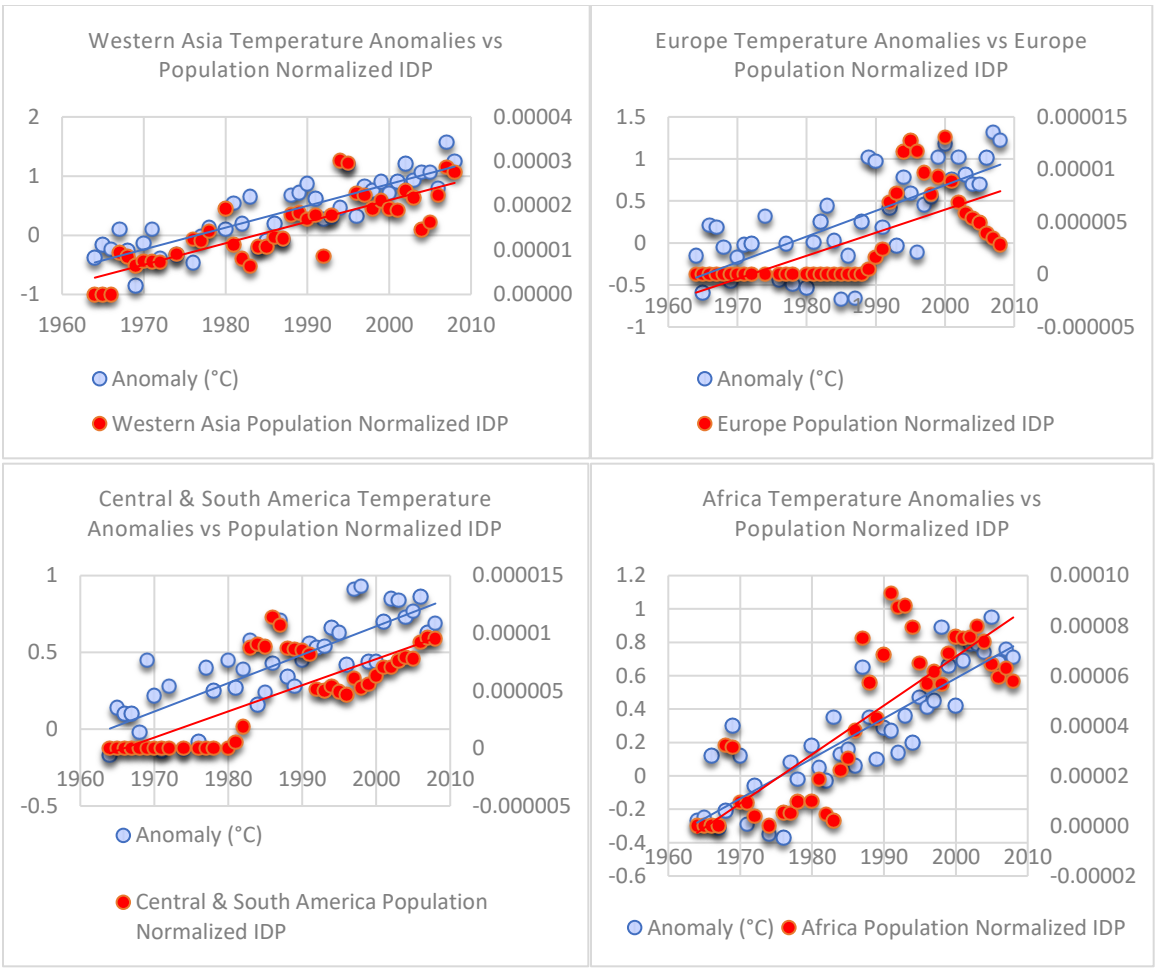
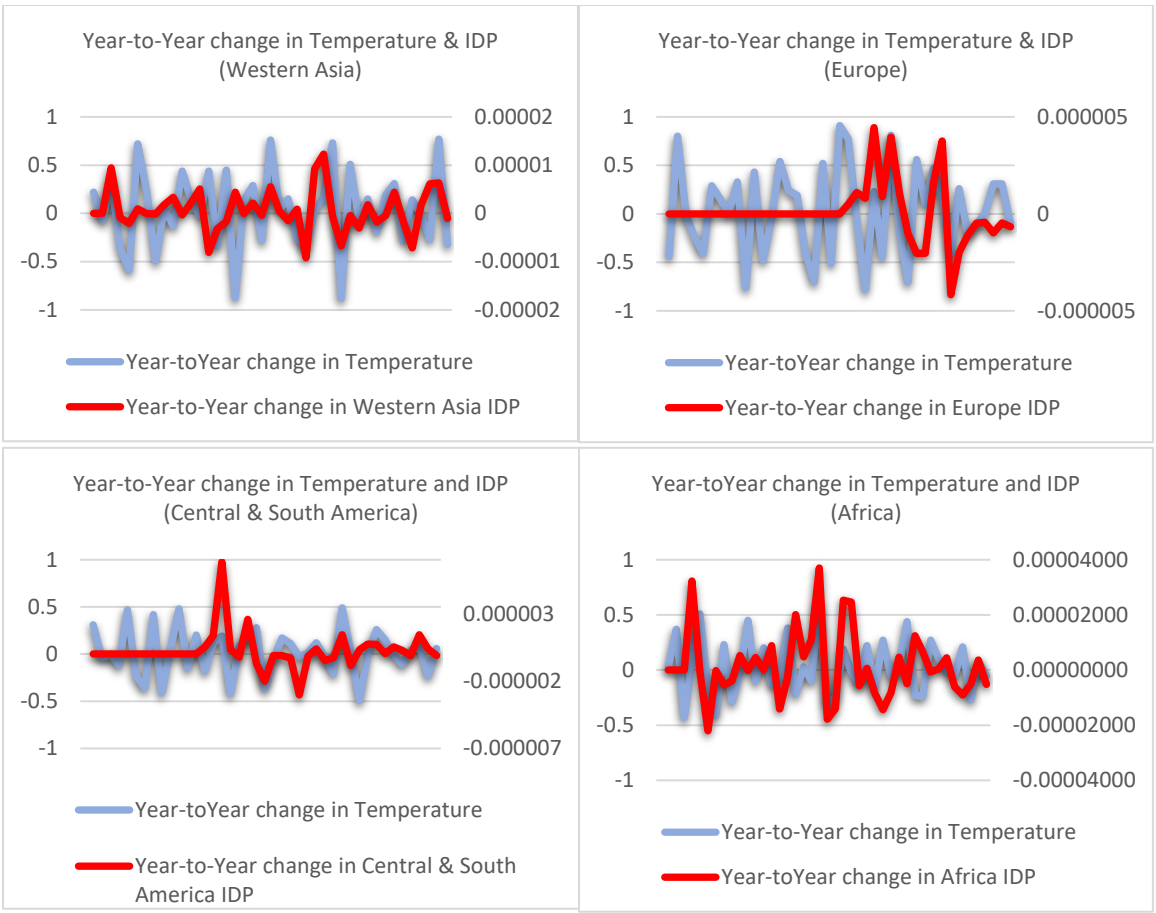


Figure 6. Year-to-year change (from 1965 to 2008) in Global Land and Ocean Temperature Anomalies vs # of Internally Displaced Persons (normalized for population growth); Years 1973, 1975, and 1979 were omitted due to lack of data. Pearson Correlation (r = 0.06) (p-value = 0.72337). The independent variable is Anomaly (°C); the dependent variable is the year-to-year change in Population Normalized IDP



Figures 7-10. Region Temperature Anomalies vs Regional Population Normalized IDPs; Years 1973, 1975, and 1979 were omitted due to lack of data. Omitted South Africa regional data due to vast displacement from systematic Apartheid. Left Y-Axes represent Temperature Anomalies (°C), Right Y-Axes represent Population Normalized IDP. Pearson Correlations: Western Asia (r = 0.76; p-value = 4.39E-09), Europe (r = 0.53; p-value = 0.0003), Central & South America (r = 0.63; p-value = 7.26E-06), Africa (r = 0.73; p-value = 3.04E-08). The independent variables are Anomaly (°C); the dependent variables are the regional Population Normalized IDPs



Figures 11-14. Year-to-year changes in regional Temperature Anomalies vs Regional Population Normalized IDPs (from 1965 to 2008); Years 1973, 1975, and 1979 were omitted due to lack of data. Omitted South Africa regional data due to vast displacement from systematic Apartheid. Left Y-Axes represent Temperature Anomalies (°C), Right Y-Axes represent Population Normalized IDP. Pearson Correlations: Western Asia (r = 0.24; p-value = 0.1273), Europe (r = 0.10; p-value = 0.2408), Central & South America (r = 0.22; p-value = 0.1703), Africa (r = 0.20; p-value = 0.2027).

All correlations in Figures 7-10 show statistically significant findings with moderate to strong correlations. This supports the hypothesis that Temperature Anomalies have a significant and casual influence over the amount of internally displaced persons, especially in developing regions. Western Asia, Central & South America, and Africa show relatively strong correlations. The countries that reside in these regions comprise of

mostly developing countries, which suggests that they are particularly vulnerable to climate change.

However, all correlations in Figures 11-14 do not have statistical significance and exhibit weak correlations. This supports the null hypothesis that year-to-year changes in Temperature Anomalies do not have a significant and casual influence over the year-to-year changes in the amount of internally displaced persons. One possible explanation for this is that the year to year changes are absorbed by countries since there have not been great swings in variation between years. Overall, the upward trends of both IDP and temperature appear strongly correlated but cannot be concluded as related; there may be other causes for the upward trends of IDP.

Fragile States Index & State Fragility Index

To the extent possible, a nation's stability can be quantified numerically and be used as a basis to evaluate nation solidity. The Fragile States Indexes of all countries were aggregated for each respective year to be representative of the entire world. The Fragile States Index measures conflict risks and holistically computes ratings based on its patented Conflict Assessment System Tool (CAST). A greater numerical value signifies a stronger and more stable nation.

In comparing the datasets of Global Land and Ocean Temperature Anomalies against the Fragile States Index 2017; there appears to be a moderately negative

correlation, with a Pearson Correlation (*r*) of -0.40 and p-value of 0.219. Considering that the p-value is above the alpha of 0.05, the correlation is not statistically significant, and the null hypothesis is kept. The data spanned from 2006 to 2017 with the year 2006 being omitted due to it being a significant outlier with a value outside of the median x 2.5 the median absolute deviation (MAD).

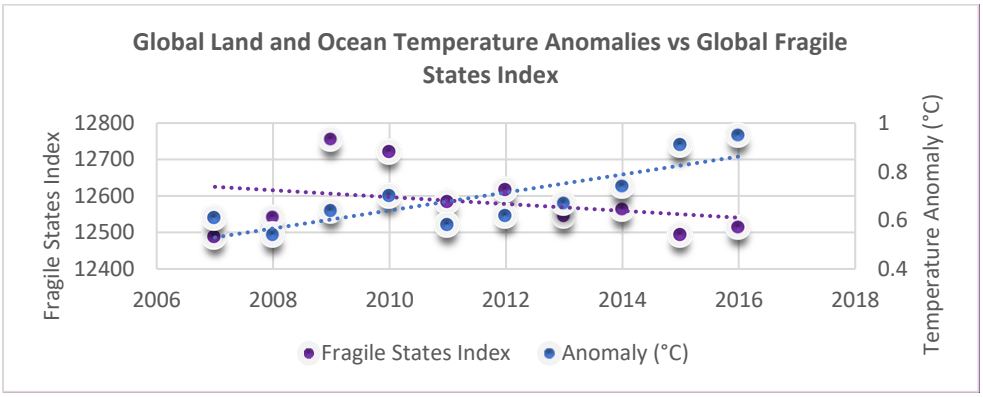


Figure 15. Global Land and Ocean Temperature Anomalies vs Global Fragile States Index. (r = -0.4; p-value = 0.219). The independent variable is Anomaly (°C); the dependent variable is Fragile States Index

Similar to the Fragile States Index, in comparing the datasets of Global Land and Ocean Temperature Anomalies against the State Fragility Index (dataset from the Center for Systemic Peace), there also appears to be a reverse correlation. But with a Pearson Correlation (*r*) of -0.76, this indicates an even stronger inverse linear relationship and a p-value of 3.97E-05. The p-value is expressively lower than the alpha of 0.05, and thus the null hypothesis is rejected.

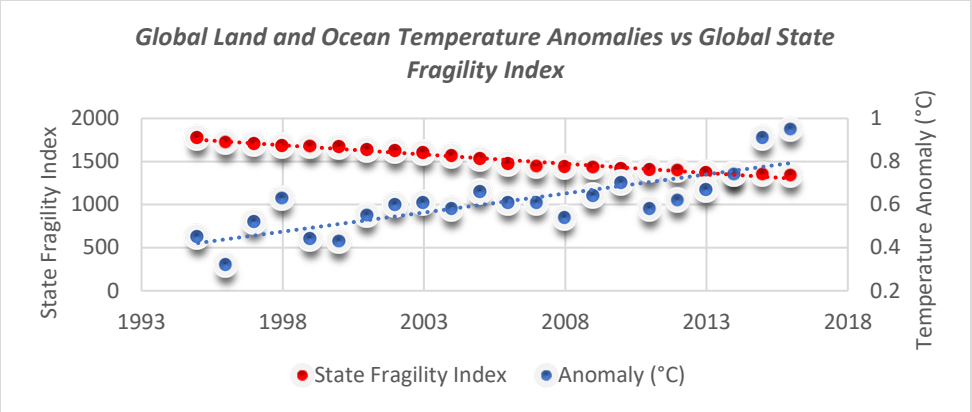


Figure 16. Global Land and Ocean Temperature Anomalies vs Global State Fragility Index. (r = -0.76; p-value = 3.97E-05). The independent variable is Anomaly (°C); the dependent variable is State Fragility Index

We see a general trend downwards over time for both the Fragile States Index and the State Fragility Index but will only consider the State Fragility Index. This downward trend is somewhat indicative of growing stability in the world overall. It should not be misconstrued to mean that as global temperatures rise and as unpredictable climatic events become more frequent, that nations are becoming more secure and stable. In consideration of the existing scientific literature on how climate change is associated with social unrest, this finding suggests that there exist strong mitigating mechanisms that the global community has adopted to help keep the peace, such as increased effectiveness of governance, quality of public services, civil service, independence from political pressures, quality of policy formulation and implementation, and the credibility of the government's commitment to such policies (World Bank databank).

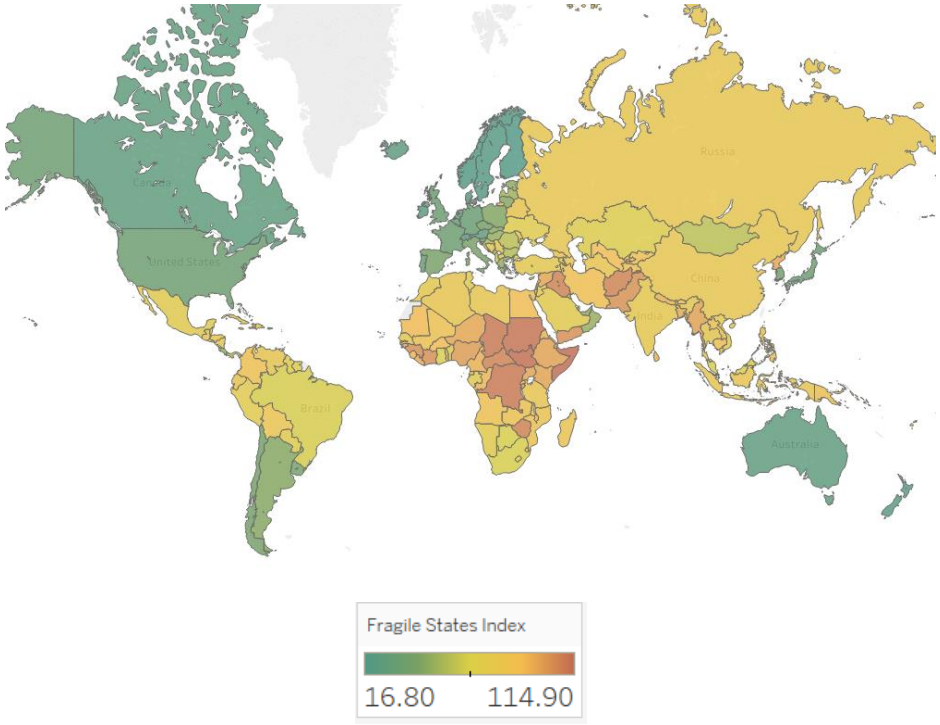


Figure 17. Map above shows the Fragile States for 2016, raw data was processed in Tableau for visualization. Analysis conducted on available years.

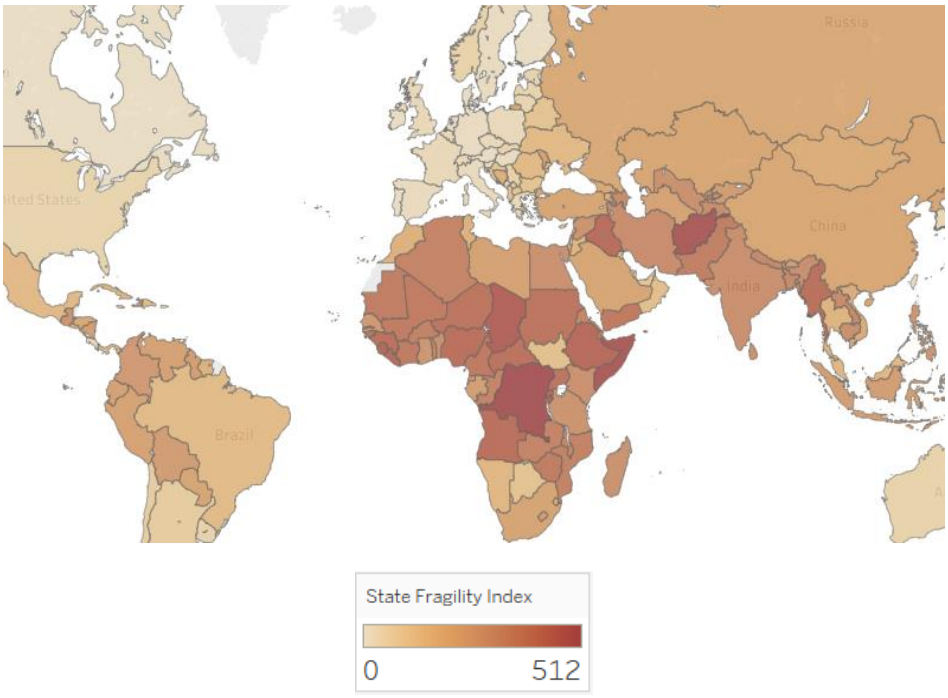


Figure 18. Map above shows the State Fragility Index for 2016, raw data was processed in Tableau for visualization. Analysis conducted on available years.

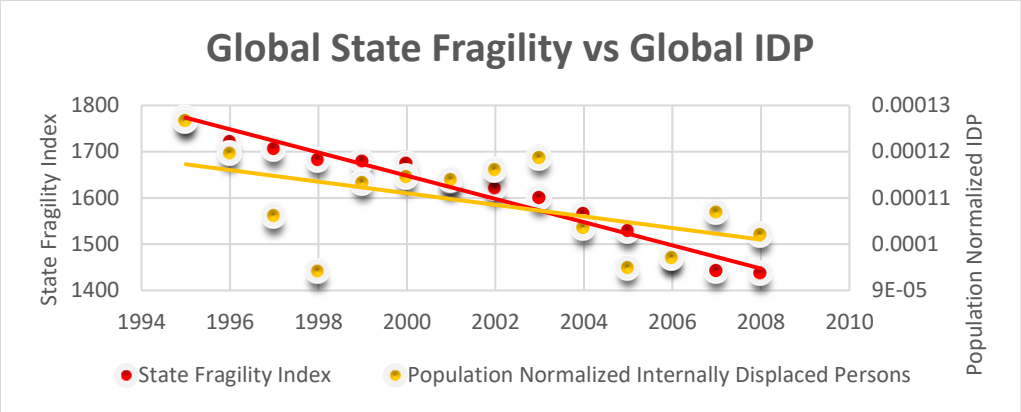


Figure 19. Global State Fragility vs Global IDP (r = 0.58) p-value = 0.029. The independent variable is Population Normalized Internally Displaced Persons, the dependent variable is the State Fragility Index

In analyzing the global State Fragility Index with the global amount of Internally Displaced Persons, a positive and moderate correlation was found (r = 0.58) with a p-value of 0.029. This statistically significant p-value allows for the acceptance of the alternate hypothesis, which states that there is a meaningful correlation between state fragility and the number of internally displaced people. The claim that the lowering of the amount of internally displaced people is consistent with the theory that state fragility is a function of domestic mass migration.

Government Effectiveness

In comparing the datasets of the State Fragility Index against Government Effectiveness (dataset from The World Bank's Worldwide Governance Indicators), there appears to be a strong reverse correlation, with a Pearson Correlation (*r*) of -0.88 and a p-value of 1.84E-06 which signals statistical significance and a rejection of the null hypothesis. This is supportive of the theory that as more effective global governance is deployed, the world drops its overall State Fragility Index over time and instability worldwide decreases. This is intuitively reasonable to predict and is consistent with the existing literature; as more people gain access to resources and services, the tendencies to revolt would decrease now that citizens will have more to lose if a collapse in society takes place. Government, public services, and rule of law coupled with proper implementation of policies to benefit citizens will serve to be a contributing factor for mitigating outside natural forces that seem to influence stability, such as temperature anomalies.

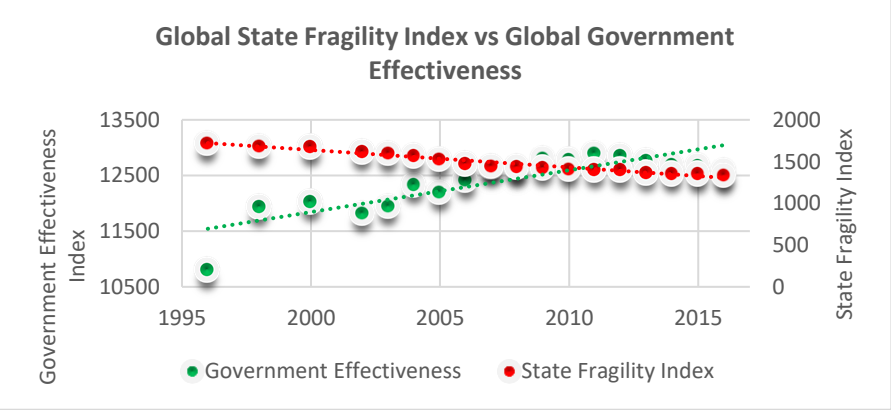


Figure 20. Global State Fragility and Government Effectiveness have a strong inverse relationship. Pearson Correlation (r = -0.88) As government services increase, fragility in the global community responds in the reverse direction. (p-value = 1.84E-06). The independent variable is State Fragility Index, the dependent variable is Government Effectiveness

The adaptive capacity of countries to deal with climate change is dependent on the ability of governments to develop and implement adaptation strategies. It is not difficult to conceptualize that countries with both a high sensitivity to climate change and a low adaptive capacity will yield a worse overall outcome when dealing with natural disasters such as storms and droughts. Countries with a highly effective government would likely have high resiliency to the natural disasters that may one day strike their borders. A key attribute of adaptive capacity is the ability for governments and civil society to design and implement action. It stands to reason that countries in a state of fragility will fare worse off than countries with little fragility. This can be further rationalized by conceptualizing that nations at or near the brink of social collapse do not have environmental hazards or preparations for disasters very high on their national agendas. Their government efforts will likely be applied to economic strategies and/or other urgent matters that are more short-term centric such as consolidating power under a totalitarian regime. Therefore, countries with weak public and civil services will be more vulnerable to climate change and particularly susceptible to its effects.

In analyzing all the countries in the lower 50% of Government Effectiveness Index, there is now a stronger correlation between the Global Temperature Anomalies and the number of people that are internally displaced within the country. Further expanding this methodology to analyze even worse off countries in the Government Effectiveness Index, such as countries in the lower 25% and lower 12.5% - it was found that the correlation between temperature anomalies and the number of internally displaced people becomes stronger and stronger for nations with lower government services. Although the correlation strength change between the lower 50%, 25% and

12.5% is minimal, the results are consistently found to be statistically significant and have strong correlation. Therefore, the null hypothesis may be rejected as we have sufficient evidence to claim that climatic temperature anomalies may influence the amount of people that are internally displaced in nations that have weak government services and structures.

Earlier, it was determined that there was a strong correlation between the global temperature anomalies and the number of globally internally displaced persons in Figure 5; the strong-moderate correlations characterized in Figures 21, 23, and 25 supports the theory that countries who lack effective governments are more vulnerable to climate change impacts. Figures 22, 24, and 26 represent the year to year changes in temperature and IDP and were found to be poorly correlated and not statistically significant.

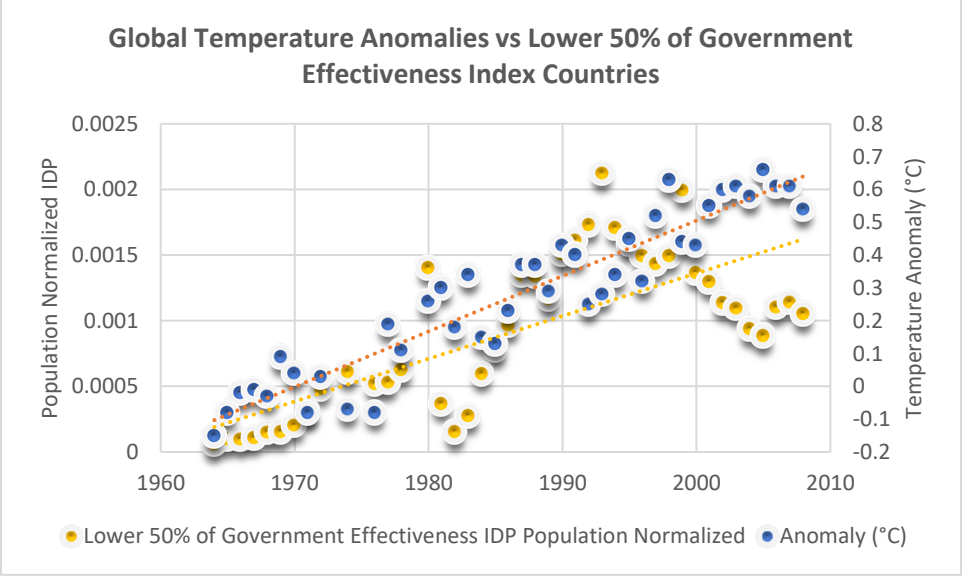


Figure 21. Countries in the lower 50% of the Government Effectiveness Index have a strong correlation with Global Temperature Anomalies. Years 1973, 1975, and 1979 were omitted due to lack of data. Pearson Correlation (r = 0.66) (p-value = 1.85E-06) The independent variable is Anomaly (°C); the dependent variable is the Lower 50% of Government Effectiveness of Population Normalized IDP.

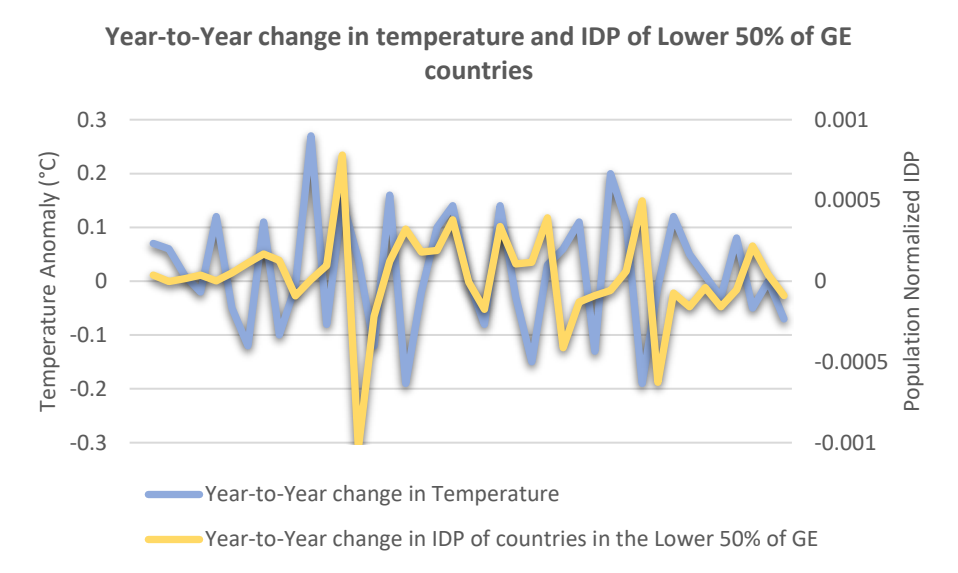


Figure 22. Year-to-year change in temperature and IDP for countries in the lower 50% of the Government Effectiveness Index. Years 1973, 1975, and 1979 were omitted due to lack of data. Pearson Correlation (r = 0.008) (p-value = 0.9613).

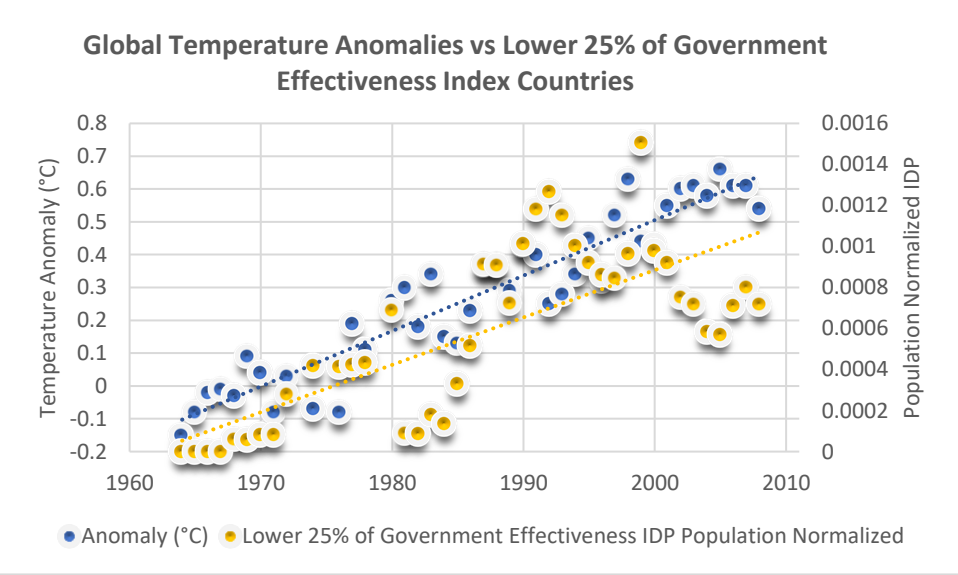


Figure 23. Countries in the lower 25% of the Government Effectiveness Index have a strong correlation with Global Temperature Anomalies. Years 1973, 1975, and 1979 were omitted due to lack of data. Pearson Correlation (r = 0.68) (p-value = 8.79E-07) The independent variable is Anomaly (°C); the dependent variable is the Lower 25% of Government Effectiveness of Population Normalized IDP.

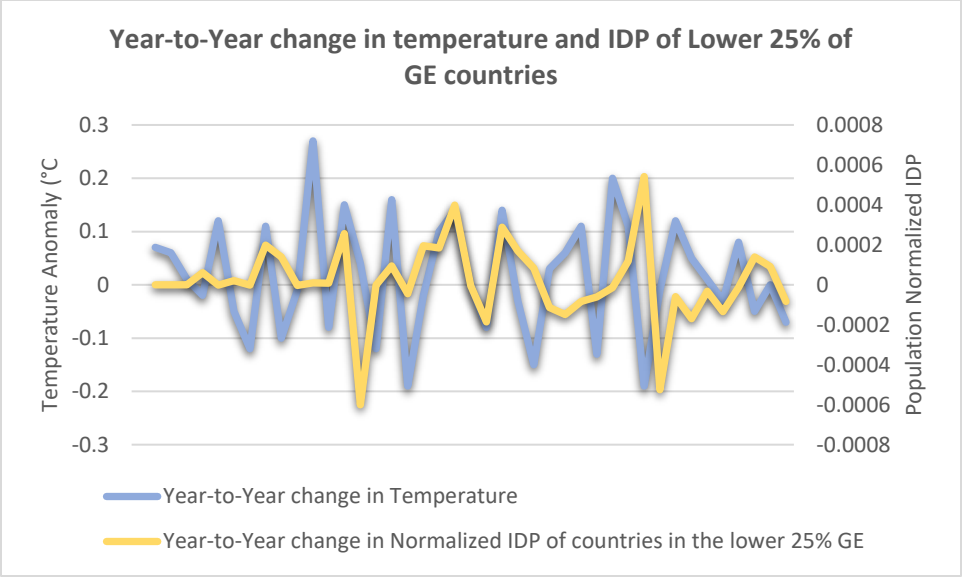


Figure 24. Year-to-year change in temperature and IDP for countries in the lower 25% of the Government Effectiveness Index. Years 1973, 1975, and 1979 were omitted due to lack of data. Pearson Correlation (r = 0.03) (p-value = 0.8465)

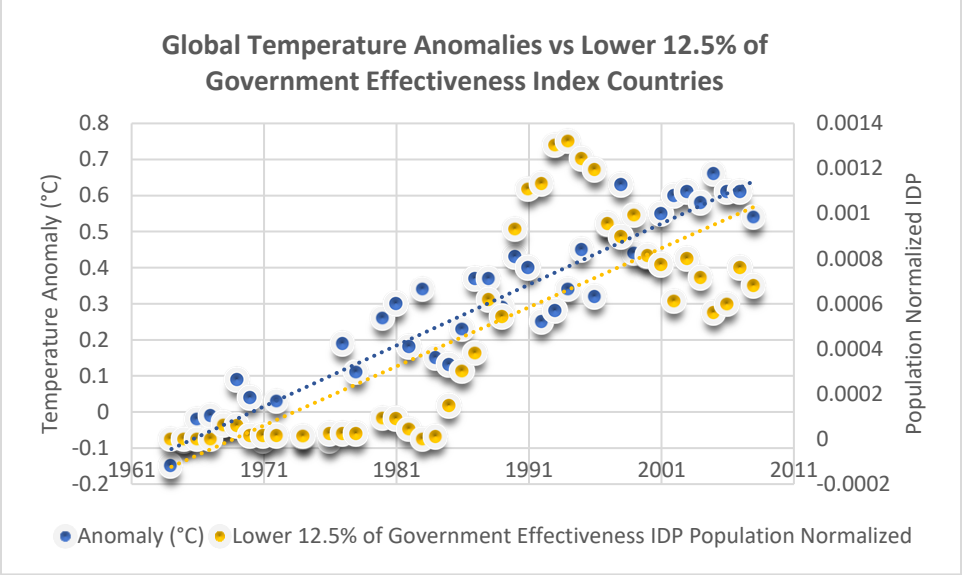


Figure 25. Countries in the lower 12.5% of the Government Effectiveness Index have a strong correlation with Global Temperature Anomalies. Years 1973, 1975, and 1979 were omitted due to lack of data. Pearson Correlation (r = 0.69) (p-value = 4.1E-07) The independent variable is Anomaly (°C); the dependent variable is the Lower 12.5% of Government Effectiveness of Population Normalized IDP.

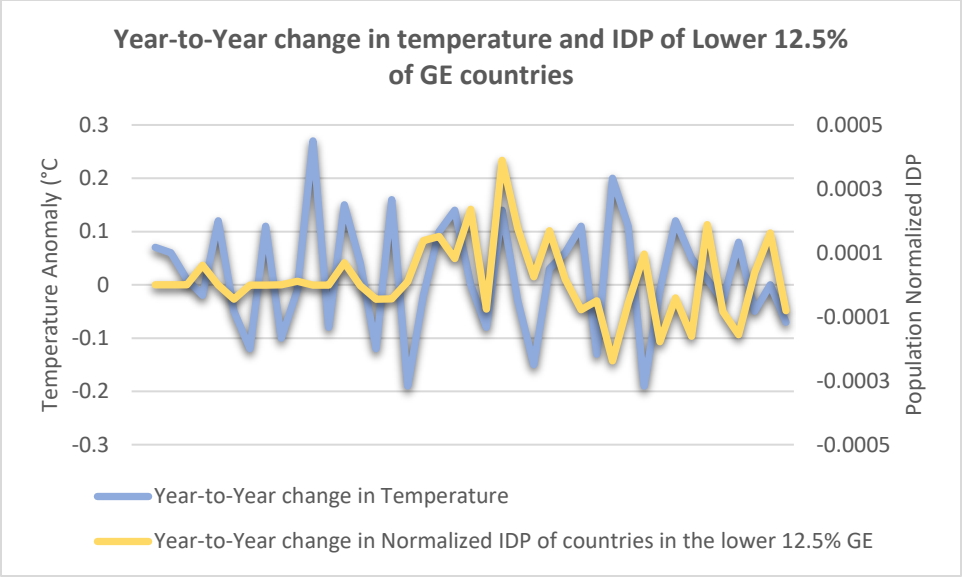


Figure 26. Year-to-year change in temperature and IDP for countries in the lower 12.5% of the Government Effectiveness Index. Years 1973, 1975, and 1979 were omitted due to lack of data. Pearson Correlation (r = 0.024) (p-value = 0.8824)

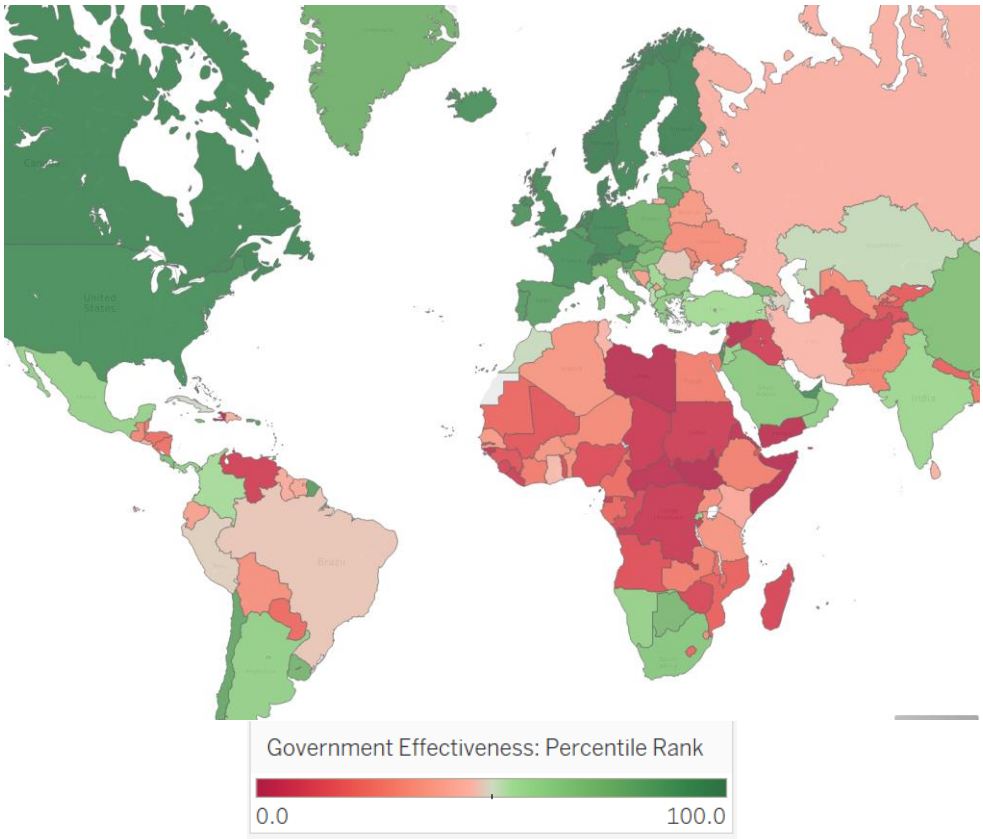


Figure 27. Countries in shades red were analyzed to determine correlative significance to Global Temperature Anomalies. Picture above shows the Government Effectiveness Index for 2016, analysis was done on years 1964 to 2008 (due to data collection halting in 2008 for Internally Displaced Persons).

The Case of Syria

On December 17, 2010, a Tunisian fruit seller had sent himself on fire and sparked what is commonly referred to as the "Arab Spring." He had self-immolated himself after the police had spilled his fruit onto the ground. This can be seen as a representative outward expression of his fellow citizens, and thus resulted in widespread protests and eventual revolution across the region through a domino effect. The events from Tunisia had spread to Egypt and Libya and ultimately to most of the Middle East which may have ultimately led to a civil war in Syria. As a result of the Syrian civil war, thousands of people died and more than a million people have been displaced (Harunoğulları, 2017). It is claimed by scientists that climate change is playing a contributing role in the drying of the eastern Mediterranean – "The magnitude and frequency of the drying that has occurred is too great to be explained by natural variability alone." (Human via NOAA, 2011) A severe drought struck Syria and the wider Levant in the years preceding the onset of strife and this too has been partly attributed to this eastern Mediterranean drying (Kelley et al., 2015). The drought that overwhelmed Syria was a noteworthy driver of its civil war with the consequential food insecurity and mass migration as key factors that marginalized civilian populations and fashioned rampant discontent, generating the conditions for violence that ultimately became reality (King, 2015). It is also worth mentioning that the borders drawn up in the Middle East by the French and British at the end of World War I are largely artificial. There have been decades of prevailing conflicts within the Middle East region related to

ethnic and religious differences. This can lead to confusing and unclear alliances when and if foreign intervention transpires.

Syria and the greater Fertile Crescent had experienced their worst 3-year drought on record prior to the social unrest. Syria was made particularly vulnerable to revolutionary tendencies after frustrations with the national government and negative social impacts caused by drought conditions. This drought had intensified their existing water and agricultural insecurity which produced cascading agricultural failures and killed off much of the country's livestock. The Bashar al-Assad regime also played a direct contributing role in conflict after government agricultural policies in 1971 sought to increase agricultural production to have Syria become food self-sufficient. Without adequate farmable land and exploiting the already insufficient water resources, the regime held no regard to sustainable practices in their policy efforts. As a result, the groundwater declined and was infrequently replenished by the winter rainfall. Farmers strongly depended on this rainfall as two-thirds of the cultivated land in Syria is rain fed (Kelley et al., 2015). One of the most direct links to the instability from the aridification was the out-migration of up to 1.5 million people from the rural farming areas to the outskirts of urban cities in both Syrian cities and neighboring nations (Kelley et al., 2015). The adaptive response of Syrian farmers to droughts in the past were generally to find other means of income such as allowing livestock owners to feed off the failed crops to receive compensation. These alternatives were short-term solutions and may have performed reasonably for 1 or 2 years, however, after approaching the 3-year mark, it likely forced farmers to migrate away from their lands in pursuit of income after all resources were exhausted. One Syrian remarked – "When the drought happened, we

could handle it for two years, and then we said, 'it's enough.' So, we decided to move to the city." (Friedman, 2013)

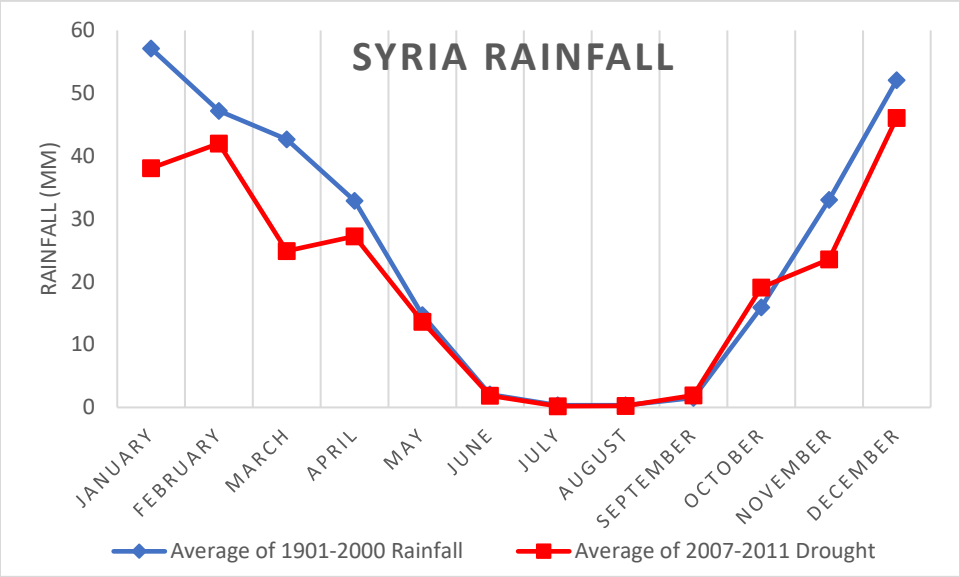


Figure 28. Average rainfall (1900-2000 in blue) and average rainfall from drought before the Syrian civil war (dataset from World Bank's Climate Change Knowledge Portal).

The drought was also particularly tough on young men who had wanted to study or marry but were unable to do either due to not being able to afford it. Families married off daughters at earlier ages because they could no longer support them (Friedman, 2013). This bulging of unemployed youths draws on a conflict theme in which a particularly large percentage of unemployed youths between the ages of 15 to 25 of an overall adult population, and where political institutions are weak, are strongly associated with increased risks for political and localized violence (Goldstone, 2002). Figure 29 reflects the unemployment status of Syria for those in the age range of 15-24, which is consistent with the aforementioned risk connection. The rapidly growing urban peripheries of Syria were overcrowded, riddled with crime and unemployment, and were neglected by the Assad regime, and became the center of the social unrest (Kelley et al.,

2015). Although it is not true to say that overall population growth or density will generally lead to violent conflicts, research has shown that abrupt changes to the status quo such as mass migrations, in which rapid and unforeseen population changes occur in a relatively short time span are strongly associated with political instability (Goldstone, 2002).

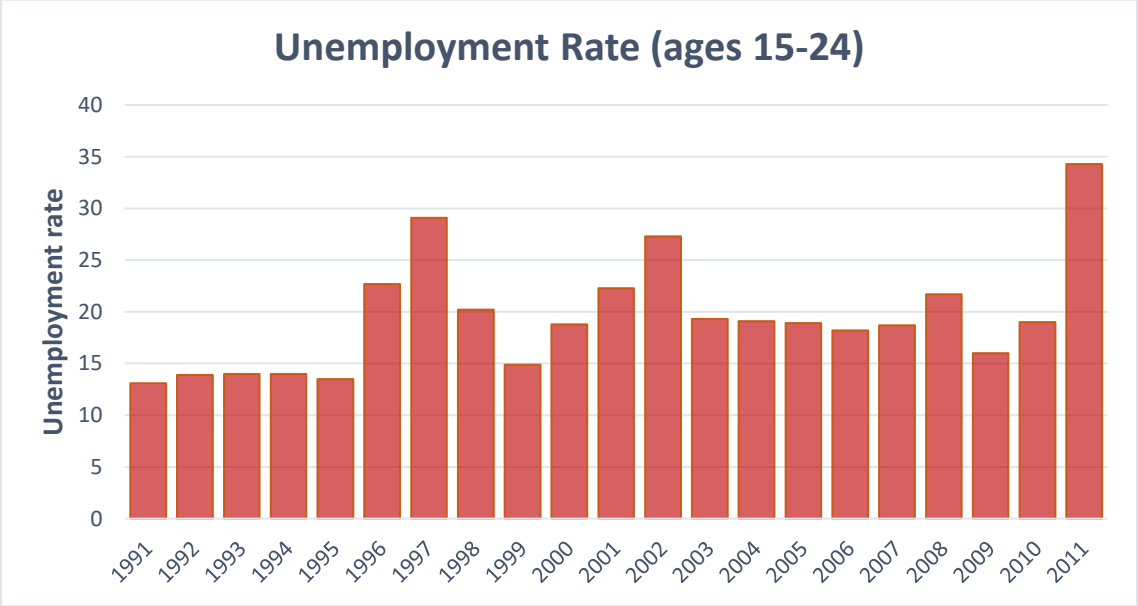


Figure 29. Unemployment rate between 1991 and 2011 (% of youths between 15 and 24) for Syria (dataset from International Labor Organization, ILOSTAT database)

Water scarcity played a telling yet complex role in creating the conditions that led to the unrest. The drought's effect on ecological systems and human systems such as food security give rise to human responses that took the form of violent conflicts and mass migrations to shanty towns in urban cities. It is clear that these aspects contributed to the rise of militant extremism, where it created a framework that allowed the Islamic State to recruit 60-70% of its forces locally. This is partly because the Islamic State controlled the routing of electricity and transportation in Syria's city, Aleppo (King, 2015). The vulnerability to drought conditions in Syria was especially severe given that the country's

total annual water withdrawal as a proportion of internal renewable water resources was as much as 160% in 2011. Global climate models also overwhelmingly agree that the region will become even drier in the future as greenhouse gas concentrations increase (Kelley et al., 2015).

Taking a targeted look at the Fragile States Index, we see Syria gradually increasing its fragility score after 2011 and nearing similar scores given to the most unstable nations in the world. The rate at which it happened also paints an illustrative picture that this rapid rise of instability is unlike anything the world has ever seen in recent years.

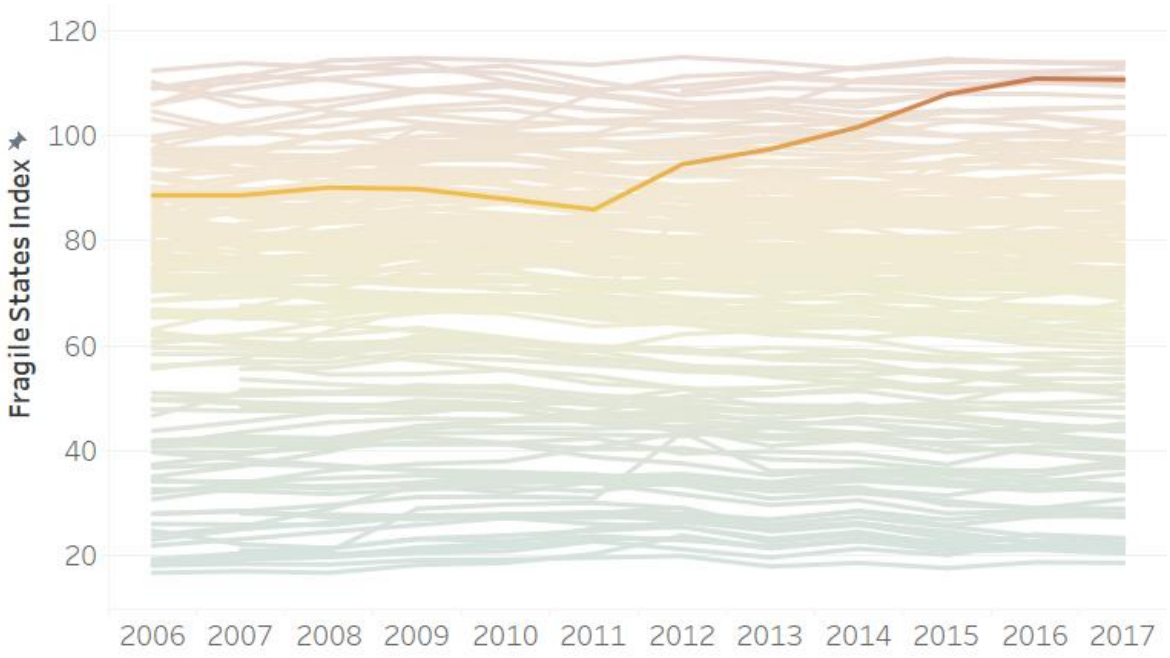


Figure 30. Fragile States Index highlighting Syria (2006 to 2017) built in Tableau

In analyzing the Government Effectiveness data and State Fragility data, we see moderate to strong response especially after the 2006 - 2010 drought. With a Pearson Correlation (*r*) of -0.61 and a p-value of less than 0.05 which permits the rejection of the

null hypothesis, and suggests that as Syria's Government Effectiveness dwindled, its State Fragility had largely responded in the opposite direction and was ultimately unable to quell its internal conflicts. The country's adaptive capacity was below what was necessary to ensure continued stability.

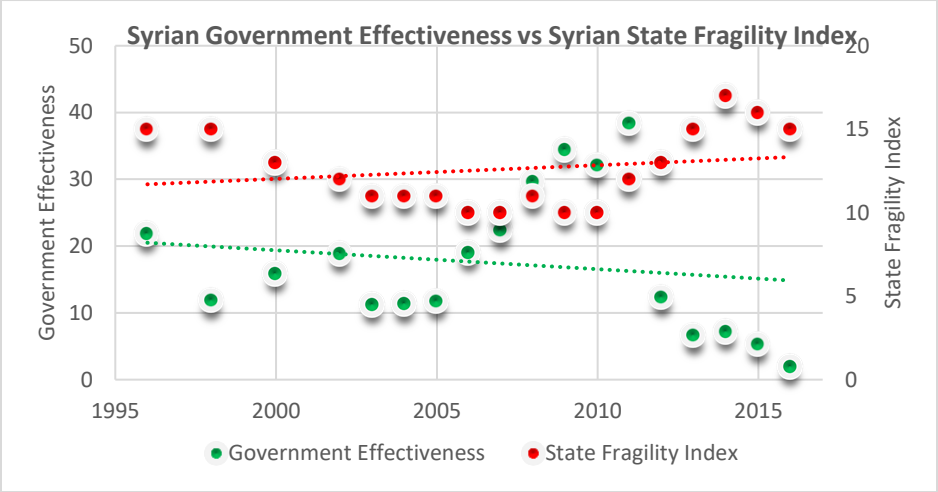
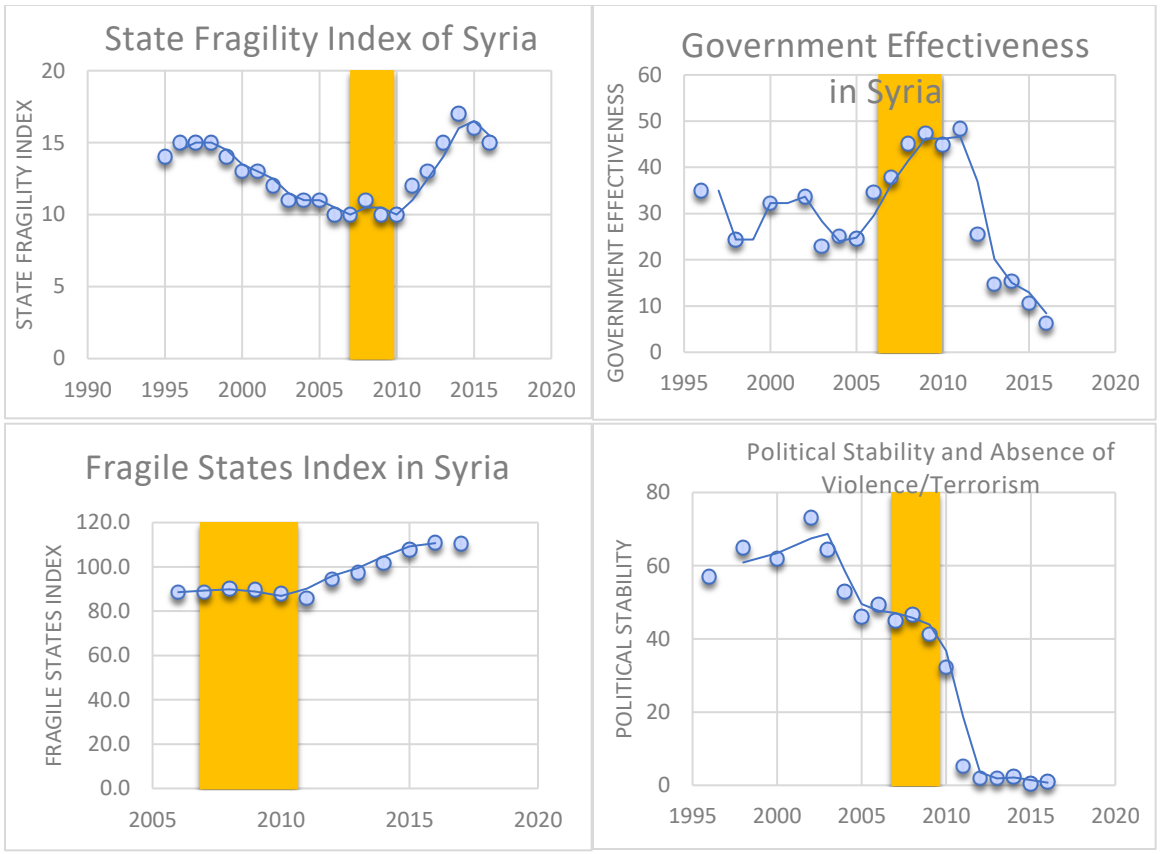


Figure 31. Syrian Government Effectiveness vs Syrian State Fragility Index reveals that as Government Effectiveness plummets, fragility increases. Pearson Correlation (r = -0.61); p-value = 0.0067. The independent variable is Government Effectiveness of Syria, the dependent variable is State Fragility Index of Syria

The orange highlighted sections of figures 32-35 below depict the 2006 – 2010 drought; trends for the State Fragility Index, Government Effectiveness, Fragile States Index, and Political Stability and Absence of Violence/Terrorism (dataset sourced from The World Bank) for Syria have all significantly reacted immediately following the drought. This suggests that a tipping point existed in the conflict. The displaced farmers in the outer borders of the urban cities, where the protests have also occurred, likely stayed in these cities to participate in these protests due to not having employment or the ability to go back to their farms. Their involvement possibly and reasonably contributed to the growing unrest in the country which ultimately lead to a civil war.



Figures 32-35. Syrian response immediately following the 2006 – 2010 drought highlighted in orange. Rapid rise in the State Fragility and Fragile States indices, rapid fall in the absence of violence/terrorism and government effectiveness indices

Conclusion

Through the experiments conducted on state fragility, temperature anomalies, government effectiveness, and the number of internally displaced people – it appears likely that climate conditions and the fragility of a nation are interrelated but are obviously not causal in both respects. The fragility of a country is likely a dependent variable of the temperature anomalies. We see statistically significant findings for relationships between temperature anomalies and the number of internally displaced people and state fragility. One powerful indicator for the level of fragility a nation has is its government effectiveness as previously concluded. Countries with a high government effectiveness rating are likely to have more control and resources available to absorb the shock of climate disasters and the gradual increase of temperatures. However, all year to year variations between temperature and IDP were poorly coorelated and were not found to be statistically significant. The assumed explanation is that the year to year changes are able to be absorbed by countries in the short term since there have not been observations of significant swings in variation between years but only an upward trend. Overall, the upward trends of both IDP and temperature appear strongly correlated but cannot be conclusively settled as interrelated; there may be other causes for the upward trends of IDP that should be explored. It is certaintly possible that temperature plays a contributing role in state fragility, but there may be other more appropriate factors such as precipication.

Countries with a high government effectiveness are presumed to also have high adaptive capacities and resiliency to be able to deal with exogenous influences from climatic events such as droughts, floods, and storms. Additional statistically significant findings include confirmation that countries with low government effectiveness ratings are more susceptible to temperature anomalies. The weaker a government is to implement public and civil services, the more vulnerable the country becomes to climate change. The trend for temperature anomalies is positive and will likely continue to climb even with the implementation of climate mitigation strategies such as the Paris Agreement. This allows the interpretation that developing countries with low resiliency and government effectiveness will likely yield greater numbers of internally displaced persons in the future assuming the positive trend of temperature anomalies holds. This will likely increase its national fragility and move countries closer to social collapse or the establishment of totalitarian states to attempt to stablize the countries. Countries that experience both negative and abrupt climatic events in combination with other disaster scenarios such as war and disease will be affected the most significantly. Natural forces can contribute to a failing state's demise but cannot be definitively proven to be the sole cause for social unrest. There likely exists other macro effects that cause the fragmentation of countries, but the climate does play a contributing role. Other factors such as economic and ethnic differences may hold more weight in their ability to disturb stability but environmental conditions may still play a significant contributing role. As temperatures and the likelihood of climate disasters occurring in nearly all regions of the world increases, the potential that climate change has on

disrupting food and water supplies and the rate of human migration may permit the extrapolation that climate change will play a larger role in state fragility in the future.

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http://sdwebx.worldbank.org/climateportal/index.cfm